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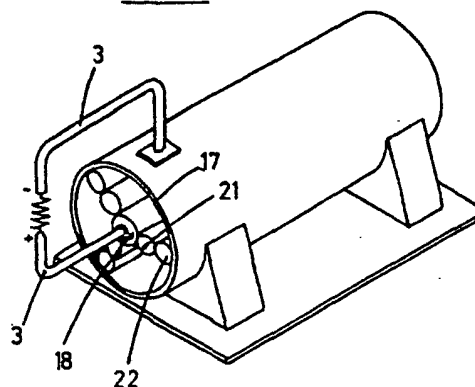
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(54) Rolling triboelectric generator.

(57) A device is described in which the electrical charges are obtained by a rolling process between two rigid dielectric surfaces of appropriate materials, one of which may be plane. There exists therein no injection of electrical charges originating from outside. The separation of the charges with the concomitant generation of electrical potentials is effected by the movements of the parts, by triboelectricification.

Amongst the uses may be mentioned the construction of electrostatic generators for teaching, research or industry and as an essential supply for fixed or portable ignition devices for boilers, cookers and gas burners.

FIG- 6



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## ROLLING TRIBOELECTRIC GENERATOR

Devices intended to generate electromotive forces are usually based on electromagnetic or electrochemical phenomena. So-called (although incorrectly) electrostatic generators or machines use processes which basically involve coulomb forces. The former generally provide high currents at low voltages; the latter usually supply weak electric currents at very high voltages. Electrostatic machines played an important role in early discoveries in the field of electricity: nowadays, they have been relegated to specific research or industrial uses. Amongst these may be mentioned the supply of high voltages for particle accelerators and for separators or precipitators.

In 1766, Ramsden constructed an electrostatic friction generator in which electrification was achieved by means of friction between glass and leather impregnated with tin bisulphide. Volta, Holtz and Voss (Chappins, J., *Leçons de Physique Générale*, Vol. II, Gauthier - Villars, Paris 1920), at around the same time, manufactured electrical machines (also called at that time electrophori) taking as a basis the phenomenon of electrification by induction or "influence". In 1883, J. Whimshurst invented his ingenious electrostatic machine which was for many years preferred by scientists and which is still used today, albeit rarely. A major advance in the field of electrostatic generators was made by R. J. van der Graaf who designed the generator which bears his name and which is currently the one in most use, both in small and in large sizes. (More, A., *Electrostatics and its applications*, Wiley, New York 1973). The "peleton" is a modified Van der Graaf generator using a system which is similar to an endless belt. In the Oak Ridge (USA) laboratory there is a peleton coupled to a 25 MV accelerator. Modern generators are usually accommodated in hermetic chambers which are filled at high pressures with some suitable gas, such as  $F_2S$ , which prevents dielectric breakdown and the harmful effects of environmental humidity. The generator which is proposed here can also operate in a hermetic enclosure and any chosen atmosphere and at the appropriate pressure. If the "coaxial" arrangement is adopted, which is one of those proposed, the external cylinder can act simultaneously as the container to be filled by the gas.

In the historical sequence of electrostatic generators, those which are proposed here have individual characteristics as set forth hereinbelow in greater detail. Various basic mechanisms are offered, based on electrifying contacts achieved by rolling, which avoids the mechanical restrictions inherent in friction. Rolling is proposed as a meth-

od of electrification and generation of voltages.

On the basis of rolling, various designs of electrostatic generator are proposed, i.e. designs of a device which situates accumulations of electrical charges of opposite sign at separate locations in space. Various proposed designs have a symmetrical configuration both in terms of the mechanical aspect and in terms of the aspect of electrical functionality, which constitutes an original element. As a (non-exclusive) example, mention should be made of the device in Figure 3 if the same radius is given to all the cylinders. In the coaxial arrangement (Figure 6) there is a certain mechanical symmetry in respect of the elements assigned to each charge, but symmetry in electrical functionality.

The coaxial design (Figure 6) also offers the particular feature that the entire electric field generated by the device is confined within the physical limits of the device, avoiding losses and interferences.

The electrostatic generator proposed in the present specification has, amongst other features, the novelty of its design, the originality of its operation, the simplicity of its basic construction, the possibility of grouping its basic elements together in a modular fashion and its adaptability to different performance requirements or demands.

The generator proposed here is called "triboelectric" because it is based on the so-called "triboelectric" properties of some materials and "rolling" because it benefits from the electrification produced by rolling in triboelectric materials.

"Triboelectrification" is the process by means of which, by placing two specific materials in surface contact, accumulations of electrical charges of respectively opposite signs are produced on said surfaces. The phenomenon originates in the transfer of electrons close to the surface from one material to the other. In order for triboelectrification to take place, it is not essential for one surface to cause friction on the other. If the triboelectrified media are insulating, the accumulations of charges will persist when there is no longer any contact between the surfaces of the media.

By trying out different pairs of materials, "triboelectric series" have been established, or rather ordered lists of materials which are positively electrified by contact with those which precede them and negatively electrified by contact with those which follow them. As an example, mention is made of that formulated by Montgomery and reproduced by W. Harper in his work "Contact and Rolling Electrification" (Oxford, at the Clarendon Press, 1967): wool-nylon-cellulose-silk-cellulose acetate-methyl methacrylate-dacron-orlon-polyvinyl

chloride-dynel-velon-polyethylene-teflon.

### DETAILED DESCRIPTION OF THE INVENTION

The rolling triboelectric generator which is the subject of the invention is intended to obtain electro-motive forces and consists essentially of active components or parts which, by means of triboelectrification, generate electrical charges, positive and negative respectively, in equal quantity and of at least two parts or components collecting said charges and intended for the transmission of said charges to terminals outside the generator.

According to one aspect of the invention, the active parts or elements of the generator consist of one or more pairs of solid bodies of materials which are suitable and distinguished from one another (for example, nylon and teflon) which occupy separate positions in the so-called "triboelectric series" and which are intended to roll on one another, generating electrical charges of opposite signs which appear separately in the bodies of different materials and situated at unequal electrical potentials.

According to another aspect of the invention, the parts or components which form the active pairs possess external surfaces which permit rolling of one on another, which circumstance arises when one of them is plane and the other cylindrical, or when the two surfaces are cylindrical.

According to yet another aspect of the invention, the mutual rolling surfaces between the active parts have a finish which is smooth or grooved in the manner of a gear or rack, the latter in the case of parts with a plane surface.

The collecting parts or components of the triboelectric generator are solid bodies, at least at the surface, which conduct electricity and are suitable for transferring the electrical charges to the terminals outside the generator.

According to another aspect, the collecting elements possess plane or curved surfaces by means of which they are in rolling contact with the respective active parts, the rolling surfaces having a finish which is smooth or grooved in the manner of a gear or rack.

According to a preferred aspect of the invention, the active parts and collecting parts have the form of a cylinder or roller with smooth or grooved surfaces.

According to a particularly important aspect of the invention, the collecting parts or components consist of two cylindrical parts which are coaxial and concentric, the outermost of which is hollow and is provided with a certain number of pairs of active parts which are dimensioned and positioned

in such a way that they can perform rolling movements relative, respectively, to the inner face of the external collecting part and to another active component which, in turn, will roll on the outer face of the inner collecting cylinder, all the surfaces of the components mentioned being smooth or grooved.

According to yet another aspect of the invention, the active parts have the form of a roller and the collecting parts are of plane form.

Another aspect of the generator which is the subject of the invention consists in that the individual active components, in whatever form, are grouped together in series or in parallel or alternatively in mixed form, it being possible, in the first case, to adapt two intermediate collecting parts into a single part common to the two modules thereby grouped together.

### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

- Figure 1 shows two solids of triboelectric nature in transverse section;

- Figure 2 shows the formation of surface charges between triboelectric components;

- Figure 3 shows a first embodiment of the triboelectric generator according to the invention;

- Figure 4 shows a second embodiment of the triboelectric generator according to the invention;

- Figure 5 shows an arrangement of cylindrical active elements together with plane collecting elements;

- Figure 6 shows a third and more important embodiment of the triboelectric generator according to the invention; and

- Figure 7 shows the grouping of several individual modules.

Rolling is a form of contact between two surfaces which is produced in successive form and which is possible only when at least one of the two surfaces is curved. As non-limiting examples, mention may be made of the rolling between two cylindrical surfaces and between one plane and another cylindrical surface. When there is rolling between two solids (1,2) of triboelectric nature, the areas where there has been rolling remain charged at the surface with electric charges of opposite signs, as illustrated in Figure number 1. Figure number 2 illustrates the formation of surface charges as a result of rolling between triboelectric media, one of which has a plane surface (9) whilst the other has the form of a cylinder or roller (8). The arrow indicates the direction of advance of the centre of the roll  $r$ . The signs of the charges depend on the respective nature of the materials.

The electrical charges generated by rolling on a surface may be removed therefrom by another rolling involving a third surface (plane or curved, as appropriate) of material which conducts electricity and which acts as a collecting device. Figure number 3 illustrates this process: the cylinders (5) and (6), shown in section, are of materials which are suitable for the rolling between them to cause triboelectrification; the cylinders (4) and (7) are of conducting material and, in rolling thereof with the above, act as collectors collecting the electrical charges. In the device shown diagrammatically in Figure number 4, triboelectrification is due to rolling between a plane (10) and a cylinder or roller (11) and the charges are collected by means of the conducting cylinders (12) and (12'). In the arrangement of the generator shown in Figure number 5, the collecting parts are the plane parts (13) and (14) and in the configuration of Figure number 6 the conducting and collecting elements are the concentric tubes (17) and (18) shown in section. In the modular device shown in Figure number 7, the cylinders or rollers which collect the charges are drawn by means of circles of small diameter, the circles of large diameter corresponding to cylinders or rollers of triboelectrifiable materials.

Having established the operating principles, it is appropriate to define the essential elements of the device proposed, which are:

A) At least two active parts or components of suitable and different materials according to the triboelectric series. At least one of them will have the curved surface.

B) The collecting parts or components constructed from materials which conduct electricity. There has to be at least one collecting part or collector for each sign of the electrical charges. The surface thereof may be plane or curved when they collect the charges from an active roller, and will necessarily have to be curved when they collect charges accumulated on a plane surface.

C) The terminals of the device connected respectively to the positive and negative collectors and capable of acting as contact outlets in order to act on external devices.

The device operates when there is rolling between the active components and between these and the collectors, all driven by an external mechanical agent. This movement gives rise to accumulations of charges in the active components, which charges are transferred to the collectors and (via external terminals) to the external devices receiving electrical charges and currents. An electromotive force arises between said terminals during operation of the device.

The electrical energy involved during operation of this device originates from the mechanical energy supplied by the external mechanical agent

which determines the rolling process. The nature, characteristics and form of application of this mechanical action lie outside the subject of this patent. This mechanical action may be applied in several ways and may directly affect one or more of the essential elements of the device which were mentioned above. The plane parts which can, alternatively, form the active elements and the collectors permit, in relation to a rolling, mutual movements which are basically those of translation. When the form thereof is cylindrical, they permit rotations and translations. The rolling results, in each case, from relative combinations of these types of movements.

According to the description of the essential elements and the operating principles, various proposals of rolling triboelectric generators are defined, which are based on said essential elements and on said basic operating principles, as described in the figures mentioned.

Figure number 3 illustrates a proposal or construction which may be considered basic or fundamental. The active parts are two cylinders of arbitrary and not necessarily equal radius, suitable for rolling on one another. Each one of them is in permanent rolling contact with a collecting cylinder (4) and (7) which, in turn, are each provided with terminals (3). The radii of the different cylinders or rollers do not necessarily have to be equal: their values are arbitrary, although they may also be equal. The axes of the different cylinders or rollers have to be parallel, but not necessarily all coplanar. The surface of the rollers may be smooth. It may also be equipped with teeth so that it has the form of a straight or helical gear. The cylinders with the form of gears increase the contact surface, enhancing the generation of surface charges, and facilitate the entrainment of all of them, applying the external mechanical agent to only one of all of them.

In the arrangement shown in Figure number 4, the active elements are the plane part (10) and the cylinder (11). The collecting elements are the rollers, smooth or provided with teeth, which may be identified by the numbers (12) and (12'). When the cylinders, in this arrangement, are provided with teeth, the plane part has to be worked in the form of a rack. In this case, electromotive forces are generated by virtue of the relative movement of the parts which remain in contact.

According to the arrangement shown in Figure number 5, the active elements, forming pairs, are organized in series, being held in suitable relative positions by means of a retaining structure. As a non-limiting example, in the figure, the existence of three pairs of active elements (15,16) has been assumed. Their form is cylindrical. The collecting parts are plane in character (13) and (14). Both the plane elements and the cylindrical elements may

be smooth on the surface or be provided with grooves or teeth which couple together. Electromotive forces are generated when the "series" of active elements is displaced relative to the plane parts, causing rolling processes which determine both the generation of accumulations of charges and collection thereof by the plane collectors.

In the arrangement of the elements shown in Figure number 6, the active elements have the form of pairs of cylinders or rollers (smooth or toothed) in permanent contact with one another and with two concentric cylinders which act as collectors, the larger of which is hollow. The active pairs (at least one) are accommodated in the space between the two collecting cylinders whose surfaces intended for rolling are smooth or toothed according to the nature of the surface of the active rollers. In the figure, a generator has been chosen, as a non-limiting example, with four pairs of active elements. The choice of the radii of the respective parts has to be such that permanent contact is ensured during rolling between the inner face of the outer cylinder and the outer surface of the active element or elements of one sign and also contact between the outer face of the inner cylinder and the active roller or rollers of the other sign. Permanent contact during rolling must also be ensured in respect of each active cylinder and its companion or complementary component. In this case, electromotive forces are generated by any of the relative movements of the parts or elements, by means of which movements rolling is produced between the rollers and cylinders involved.

Figure number 7 shows the grouping together of various individual modules. The grouping together of various modules with the characteristics of that described in Figure number 3 has been taken as a non-limiting example. The left-hand branch and the right-hand branch show various modules (to be exact, two) grouped together in series. The two collecting elements by means of which the connection is established, (19) and (20), may be adapted into a single element. The grouping together of modules in series increases the voltage between external terminals. In turn, the two branches are connected in parallel, which increases the current supply. In the figure, the larger circles show, in section, the active rollers, whilst the smaller circles show, in section, the collecting cylinders.

#### Claims

1. Rolling triboelectric generator intended to obtain electromotive forces, characterized in that it comprises active components which, by means of triboelectrification, generate positive and negative electrical charges in equal number, and in that it

comprises components collecting and transmitting said charges to external terminals.

2. Triboelectric generator according to Claim 1, in which the active components are one or more pairs of solid bodies of different materials which roll on one another,

3. Triboelectric generator according to Claim 1, in which the active components possess plane or curved external surfaces which permit rolling of one on another.

4. Triboelectric generator according to Claims 1 and 3, in which the mutual rolling surfaces between the active components are smooth or toothed.

5. Triboelectric generator according to Claim 1, in which the collecting and transmitting components are plane or curved solid bodies which conduct electricity at least on their surface.

6. Triboelectric generator according to Claim 1, in which the collecting components possess smooth or toothed surfaces.

7. Triboelectric generator according to Claims 1 to 6, in which the active components and the collecting components are of cylindrical form with smooth or toothed outer surfaces.

8. Generator according to Claims 1 to 6, in which the collecting components are coaxial and the active components are one or more pairs of bodies of rotation contained in the space between the collecting components.

9. Triboelectric generator according to Claims 1 to 6, in which the active components are in the form of a roller and the collecting components have a plane form.

10. Triboelectric generator according to Claim 1, in which the active components and the collecting components are grouped together in series, in parallel or in mixed form.

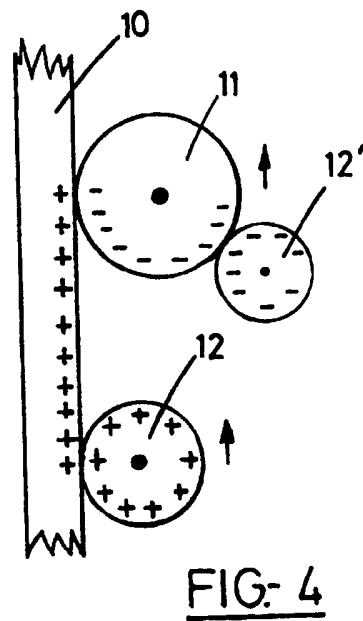
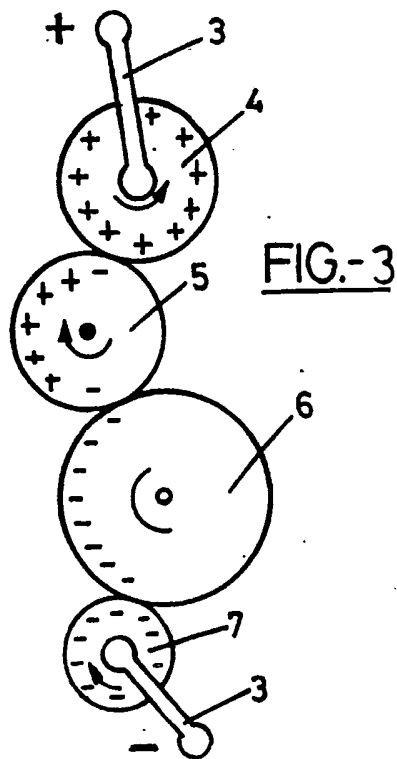
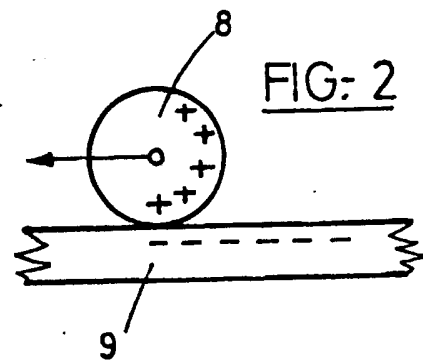
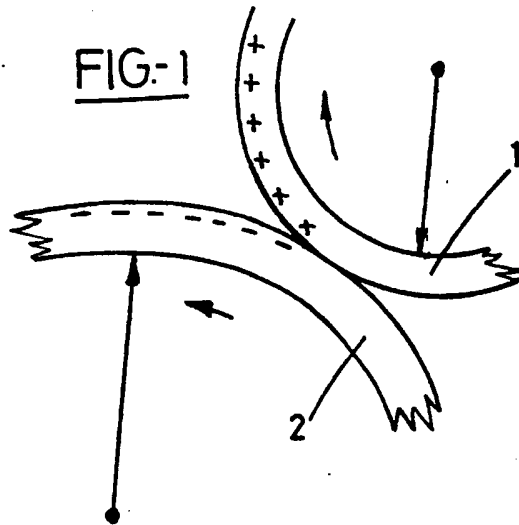


FIG.- 5

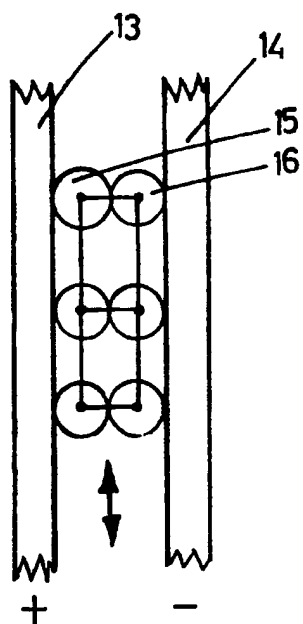


FIG.- 6

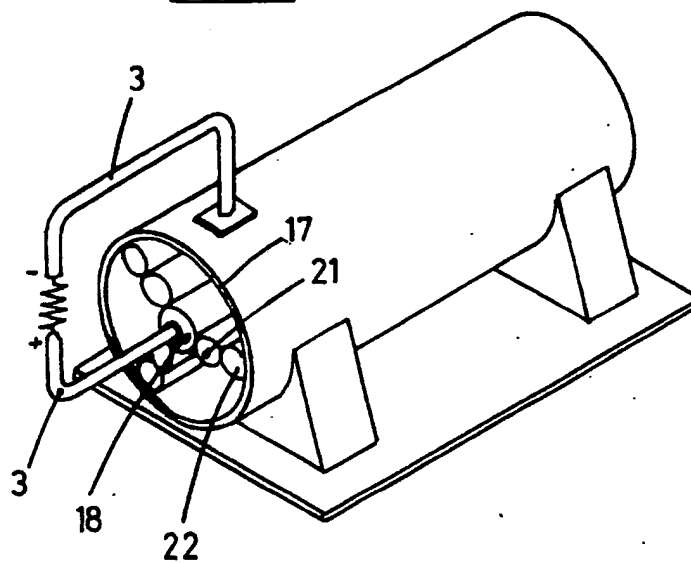
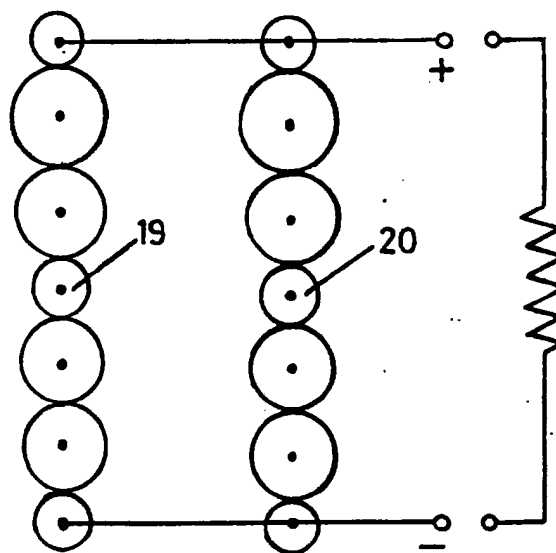


FIG.- 7





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# EUROPEAN SEARCH REPORT

Application Number

EP 89 50 0108

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 086 131 (E.W. BALLENTINE) * claims 1-3; claims 11-13; column 4, line 1 - column 5, line 70; figure 4 *	1-6,10	H 01 2 N1/04
X	DE-C- 58 777 (V. HIRBEC) * column 1, paragraph 3 - column 2, paragraph 2; claim; figures 1-3 *	1-6	
A	BE-A- 697 718 (PHILIPS GLOEILAMPENFABRIEKEN) * figure 3; claim II-6; page 6, paragraph 3 - page 7, paragraph 2 *	1-6	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 02 N 1/00
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 11-01-1990	Examiner CLOSA D.
<b>CATEGORY OF CITED DOCUMENTS</b>			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document; but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	